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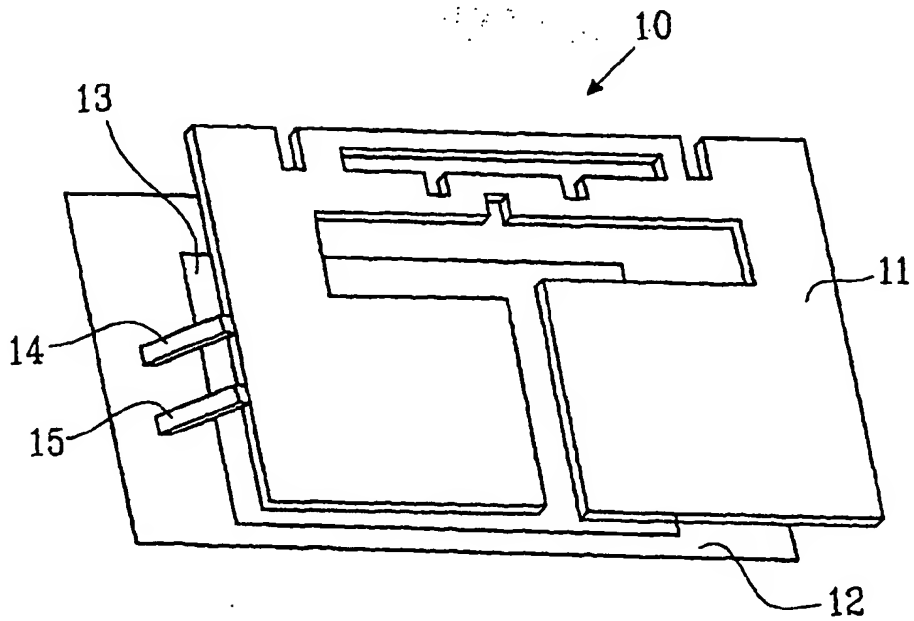
(54) Title: ANTENNA ARRANGEMENT



(57) Abstract: The present invention relates to an antenna arrangement (10), preferably of PIFA (Planar Inverted-F Antenna) type, which comprises conducting plate (11) covering a ground plate (13), said conducting plate being provided with a first slot (19) as capacitive load (C). The conducting plate (11) is arranged with a second slot (18, 19) providing a conductive load (L).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

TITLE

ANTENNA ARRANGEMENT

TECHNICAL FIELD OF THE INVENTION

The present invention relates to an antenna arrangement, and specially an antenna arrangement of PIFA (planar inverted-F antenna) type.

DESCRIPTION OF THE RELATED ART

The wireless forms of communications have become a standard way of communication. There are many types of means for conducting a wireless communication, such as cordless telephones, lap top computers with wireless modems, satellite and cellular telephones.

The communication device, i.e. the mobile handsets rapidly become smaller and lighter and the globalization demand, multiple communication functions and standards being combined into a single unit, e.g. for communicates in multiple frequency bands.

There are a variety of different radiotelephone systems in use today. These include different analogue or digital CDMA (Code Division Multiple Access) and TDMA (Time Division Multiple Access) based systems like GSM (Global System for Mobile telecommunication), AMPS (Advanced Mobile Phone System), DAMPS(Digital Advanced Mobile Phone System), PCS (Personal Communication Services), DCS (Digital Communication System) PCN (Personal Communication Networks), PDC 800 and 1500 and different cordless telephone systems.

Different systems operate in different frequency bands, thus requiring different antennas for maximum efficiency.

Over the past years, since the first PIFA (planar inverted-F antenna) was disclosed, there have been several types of microstrip antennas with both a feed and a ground connection. Several methods of unique feeding or loading arrangements of the antenna (or combinations of both)

have been disclosed.

In order to reduce the size of a microstrip antenna, the antenna requires a load, either capacitive or inductive. An inductive load consists of slots within the antenna and a capacitive load is formed by either a dielectric material placed at certain locations or by bringing the metal closer to the ground plane. Both methods of forming a capacitive load require three-dimensional structures.

To address multiple frequency bands, there are several know methods. A parasitic (or galvanic coupled) element may be placed above the antenna (where this parasitic element would have a resonance at a higher frequency band). This layered construction of the antenna requires more complex mass-production techniques than single layer microstrip antennas.

Alternatively, the antenna may consist of several elements parallel to each other. Although the antenna consists of only one layer, the parallel elements have a strong coupling, making it difficult to tune each element separately. A third method consists of making slots in the antenna at certain locations. This method, however, requires unloaded antennas.

Prior art discloses several technics:
US 4,766,440 describes a patch antenna with an U-shaped slot in the middle fed by a stripline feed. The antenna according to this document do not use an additional connection to ground.

US 4,692,769 teaches using a large $\lambda/2$ patch with a slot to excite two different radiation modes. A dual band antenna is created with two different modes of radiation.

In US 4,356,492 several different patches connected to a common feed line to create multiple bands are used.

A planar inverted-F antenna is described in US 5,764,190, that is provided with a capacitive load that allows the dimensions of the antenna to be reduced from a conventional $\lambda/4$ to $\lambda/8$.

SUMMARY OF THE INVENTION

The main object of the present invention is to overcome the drawbacks of the prior art by means of a simple but yet an efficient antenna.

Another object of the present invention is to provide an antenna arrangement, which allows a multiple band antenna on a single microstrip layer without strong coupling between the bands.

Therefore an antenna arrangement, preferably of PIFA (Planar Inverted-F Antenna) type is provided, which comprises conducting plate covering a ground plate, said conducting plate being provided with a first slot as capacitive load. The conducting plate is further arranged with a second slot providing a pure conductive load.

In an advantages embodiment the conducting plate is provided with connections to ground and feeding, which connections are probes.

For generating, e.g. dual-band frequencies, the first and second slots are so arranged that in said conducting plate when fed by a current, two currents flowing in two paths are generated. Consequently, a dual band antenna is created with each band at the same mode, by creating said two different current paths.

To control characteristics of the antenna said first slot has a width and by varying said width, the capacitive load is varied and said first slot has a width and by varying said width, the conductive load is changed.

In a preferred embodiment said second slot is a delimited opening arranged in a longitudinal direction of the conducting plate. It may also comprise a substantially L-shaped opening.

In another preferred embodiment said second slot is a substantially circular opening.

In a preferred embodiment said first slot is substantially T-shaped having an open and at one edge of the conducting plate, and it is arranged substantially in the middle of the conducting plate.

In an advantageous embodiment, to reduce the size of the antenna the conducting plate is at least partly bended.

Preferably, the antenna includes a third slot.

The antenna arrangement is a single, dual and/or multi band antenna.

According to a method of providing a single, dual and/or multi band antenna arrangement, preferably of PIFA (Planar Inverted-F Antenna) type, which comprises a conducting plate covering a ground plate, said conducting plate being provided with a first slot as a capacitive load the conducting plate is arranged with a second slot providing a conductive load and the characteristics of said antenna are varied by varying dimensions and/or geometries of said slots.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention will be further described in a non-limiting way under reference to the accompanying drawings in which:

Figs. 1a and 2a are sections of a conducting plate provided with slots;
Figs. 1b and 2b are electrical representations of the conducting plates shown in figs. 1a and 2a;
Fig. 3 is a schematic illustration in perspective of a first embodiment of the invention;
Fig. 4 illustrates a frontal, elevation view of the antenna arrangement according to fig. 3;
Fig. 5 is the electrical wiring diagram representation of the antenna according to fig. 3; and
Figs. 6 to 10 schematically show in perspective alternative embodiments of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The theory behind the invention will be described with respect to the illustrations of figs. 1a, 1b, 2a and 2b. By providing an open slot 6 on a conducting plate 5 a capacitive load element is obtained when a current flows through it. The slot 6 of fig. 1a corresponds to a substantially large inductance L_1 and small capacitance C_1. The slots of 6 and 7 of Fig. 2a correspond to a substantially large capacitance C_2 and small inductance L_2. The current paths for I_1 and I_2 are shown in fig.2a. By changing the gap distance *d*, it is possible to change the capacitive load for (in this case) two bands, while changing the width *w* of the inner slot 7, it is possible to change the inductive load on either both bands or a single band, which depends on the feeding arrangement.

Figs. 3 and 4 in a schematic way illustrate the antenna arrangement 10 according to the invention.

In order to achieve multiple band performance on a single microstrip layer without strong coupling between bands, an RLC circuit antenna is preposed.

The antenna arrangement 10 consists of a conducting plate 11 connected to a supporting member 12 such as a printed circuit board, provided with a ground plane 13, which is entirely or partly covered by said conducting plate 11. The conducting plate 11 is connected to the ground plane 13 and feeding (not shown) is provided through conductors 14 and 15. Thus, the present invention uses a probe feed which introduces extra inductance instead of a stripline or microstrip feed of prior art. Moreover, the invention presents only a single patch to create multiple frequencies.

Now referring to fig. 4, the conducting plate 11, which in this example is essentially rectangular- shaped and has a pair of first (short) edges 16 and a pair of second (long) edges 17, is arranged by a number of recesses or slots constituting an inductive and a capacitive load, both loads are unique. The slots can be provided in the conducting plate in varies ways and used to vary a resonant frequency since a current has to travel a longer path. The slots are denoted: 18 and 19, where 18 refers to a slot extending substantially in parallel to one of said second edges 17 and 19 refers to a substantially T-shaped slot having a first section 20

substantially in parallel with one of said first edges 16 and a second section 21 substantially in parallel with one of said second edges 17.

Slot 18 includes further slots 18a and 18b substantially transverse to its longitudinal axis. A further slot 21a substantially transverse to the longitudinal axis of the slot 21 is provided, substantially as an extension of slot 20. The conducting plate 11 is provided with further notches 22a and 22b, preferably at each end section of the slot 18.

The electrical diagram of the antenna is shown in fig. 5. The capacitive load C is formed by the two ends of the antenna coming within close proximity of each other, i.e. the slot 20. This forms a capacitive load for both frequency bands. The inductive load L is formed by using both slots 19 and 18. The resistors R are inherent resistance of the conducting plate. The slot increases the inductive load by focussing the magnetic field and creates a third frequency (substantially much higher). Returning to fig. 4, two currents I_1 and I_2 flowing in two paths shown by arrows are generated. Consequently, a dual band antenna is created with each band at the same mode, by creating said two different current paths.

The slots, one with the open end (to air) 19 and the second the closed slot 18 (no open ends) are so arranged that the closed slot 18 creates a pure inductance loading, whereas the open slot 19 (dependent on location) provides both a capacitive and an inductive load. By placing the open slot 19 near the middle of the antenna and varying its geometry, the loading capacitance can be varied, while by changing the shape of the closed slot 18, the loading inductance is varied, each somewhat independently of the other load. The shapes of the slots are important since they have a direct effect on the loading values. An oblong closed has different inductance than a circular opening. Depending on the antenna geometry, either shape can be used for different effects. Moreover, the open slot provides a capacitive load at the end of each current path. The closed slot provides a pure inductance for either band or just one band (depending on location within the antenna).

Preferably, the accordingly produced antenna is $\lambda/4$ with a connection to the ground. Moreover, it is an advantage that the antenna dimensions can be tuned to provide 2 bands, while adjusting the slot's 18 dimensions to provide a third band, for example the 2 bands could correspond to

GSM900/GSM1800 and the third band could be the ISM (Industrial, Scientific and Medical) Band.

Additional alternative embodiments realising the invention are disclosed in figs. 6-10. In all figures 11 denotes the conducting plate, 18 the first slot, 19 the second slot and 14/15 feed/ground connections. In fig. 6, the first slot 18 is arranged as a circular opening at one corner section of the substantially rectangular conducting plate and the second slot 19 is arranged on one edge of the plate extending towards the inside of the rectangular conducting plate. Ground and feed connections are arranged at one side of the second slot 19.

In fig. 7 an additional rectangular slot 18a is arranged at one end of the second slot 19 arranged on one edge of the plate extending towards the inside of the rectangular conducting plate. Moreover, the plate 11 is provided with a bended portion 11a, which lengthens the antenna in small spaces.

In the embodiment according to fig. 8, which is similar to the embodiment of fig. 6, the second slot 19 is substantially T-shaped and the first slot 18 is substantially circular.

In the embodiment according to fig. 9, which is similar to the embodiment of fig. 8, the first slot is an angled rectangle (substantially L-shaped) extending partly in one side and partly in the upper side of the second, substantially T-shaped slot 19.

The embodiment of fig. 10 comprises an oblong rectangular conducting plate 11 provided with a substantially rectangular first slot 18 and a second slot 19, and has its feeding and ground connections at one short edge. Moreover, the slot 18 may be arranged at any side of the second slot.

The antenna arrangement according to the invention can be used in any device with a need for receiving and/or transmitting electro-magnetical waves, and because of its small size it is most suitable for use in cellular phones or the like.

The invention is not limited to the shown embodiments but can be varied in a number of ways, e.g. through combination of two or more embodiments shown, without departing from the scope of the appended claims and the arrangement and the method can be implemented in various ways depending on application, functional units, needs and requirements etc.

CLAIMS

1. An antenna arrangement (10), preferably of PIFA (Planar Inverted-F Antenna) type, which comprises a conducting plate (11) covering a ground plate (13), said conducting plate being provided with a first slot (19) as a capacitive load (C),
characterised in,
that said conducting plate (11) is arranged with a second slot (18, 19) providing a conductive load (L).

2. The antenna arrangement of claim 1,
characterised in,
that said conducting plate (11) is provided with connections (14, 15) to ground and feeding.

3. The antenna arrangement of claim 2,
characterised in,
that said connections (14, 15) are probes.

4. The antenna arrangement according to any of preceding claims,
characterised in,
that said first and second slots are so arranged that in said conducting plate (11) when fed by a current, two currents (I_1; I_2) flowing in two paths are generated.

5. The antenna arrangement of claim 4
characterised in,
that a dual band antenna is created with each band at the same mode, by creating said two different current paths.

6. The antenna arrangement according to any of preceding claims,
characterised in,
that said first slot has a width (d) and by varying said width, the capacitive load (C) is varied.

7. The antenna arrangement according to any of preceding claims,
characterised in,
that said first slot has a width (w) and by varying said width, the conductive load (L) is changed.

8. The antenna arrangement according to any of preceding claims,
characterised in,
that said second slot (18) is a delimited opening arranged in a longitudinal direction of the conducting plate.

9. The antenna arrangement according to any of preceding claims,
characterised in,
that said second slot (18) comprises a substantially L-shaped opening.

10. The antenna arrangement according to any of claims 1-8,
characterised in,
that said second slot (18) is a substantially circular opening.

11. The antenna arrangement according to any of preceding claims,
characterised in,
that said first slot (19) is substantially T-shaped having an open and at one edge of the conducting plate.

12. The antenna arrangement according to any of preceding claims,
characterised in,
that said first slot (19) is arranged substantially in the middle of the conducting plate.

13. The antenna arrangement according to any of preceding claims,
characterised in,
that the conducting plate is at least partly bended.

14. The antenna arrangement according to any of preceding claims,

characterised in,

that it includes a third slot (18a).

15. The antenna arrangement according to any of preceding claims,

characterised in,

that it is a single, dual and/or multi band antenna.

16. Method of providing a single, dual and/or multi band antenna arrangement (10), preferably of PIFA (Planar Inverted-F Antenna) type, which comprises a conducting plate (11) covering a ground plate (13), said conducting plate being provided with a first slot (19) as a capacitive load (C),

characterised by,

arranging said conducting plate (11) with a second slot (18, 19) providing a conductive load (L).

17. the method of claim 16,

characterised in,

that characteristics of said antenna are varied by varying dimensions and/or geometries of said slots.

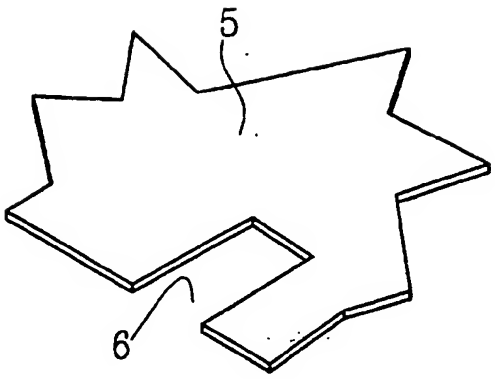

FIG.1a

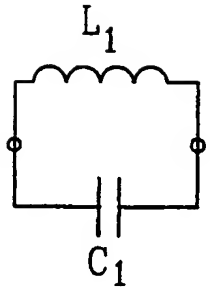

FIG.1b

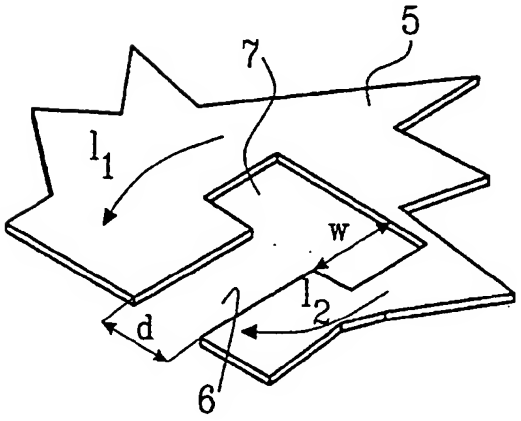

FIG.2a

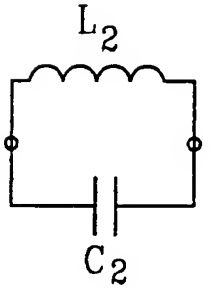

FIG.2b

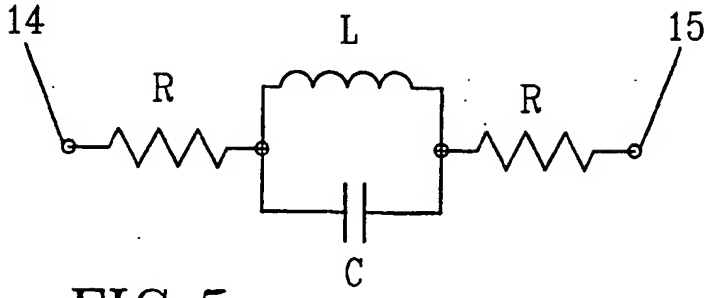

FIG.5

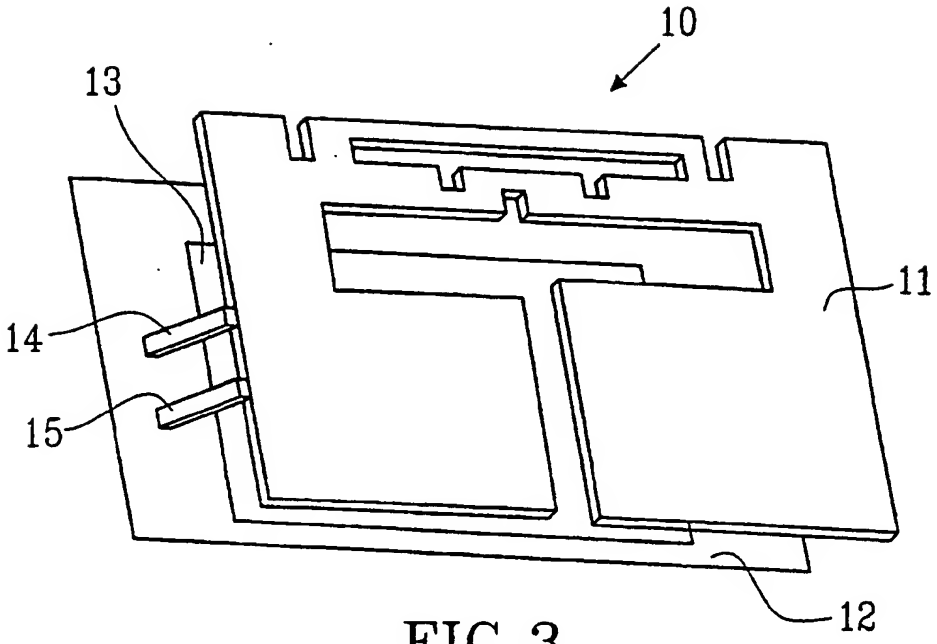
10
13
11
14
15
12

FIG.3

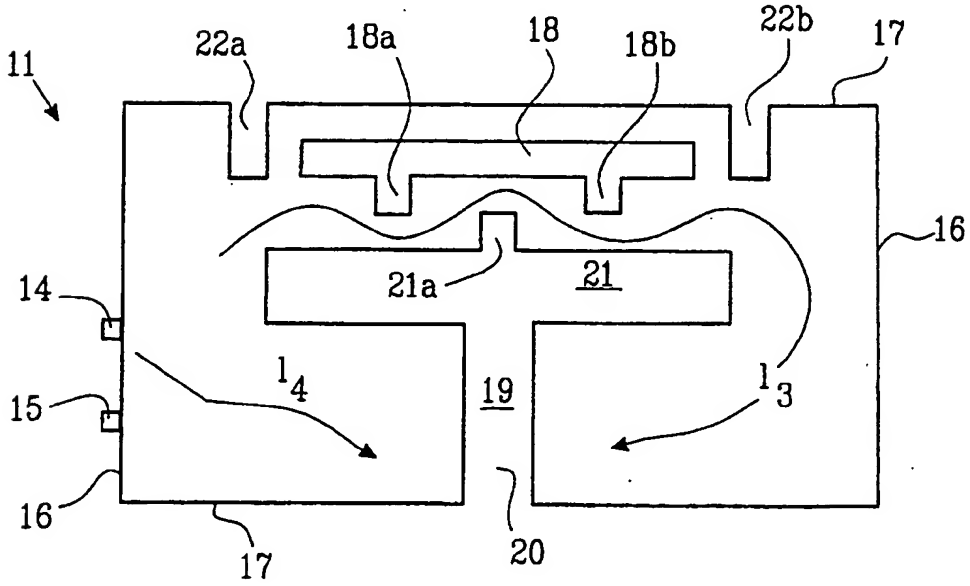
11
22a
18a
18
18b
22b
17
16
14
21a
21
15
l_4
19
l_3
16
17
20

FIG.4

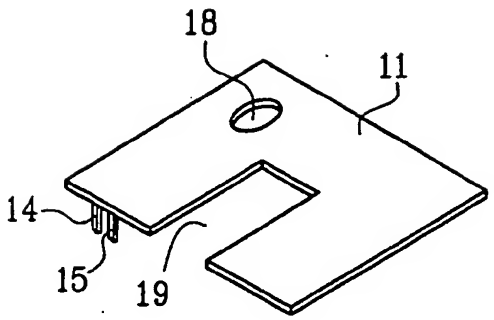

FIG.6

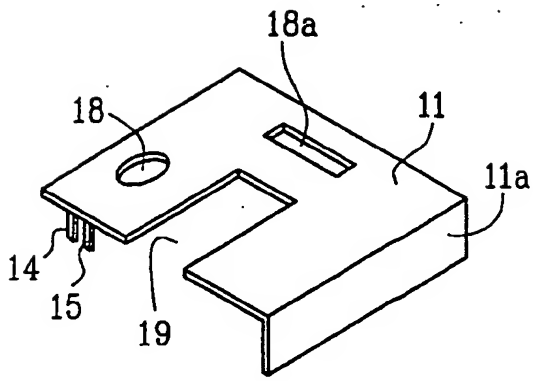

FIG.7

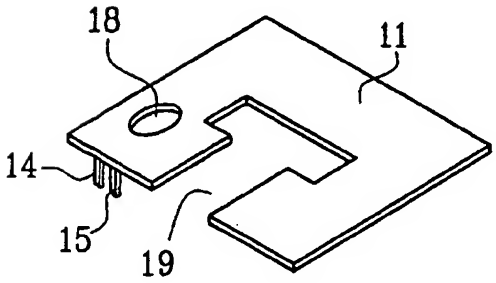

FIG.8

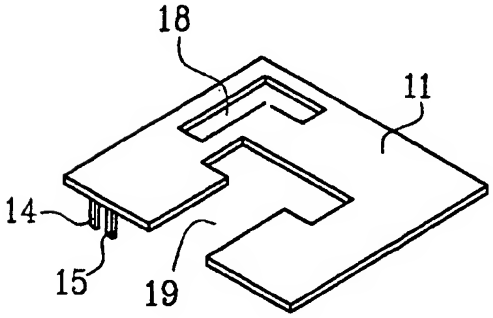

FIG.9

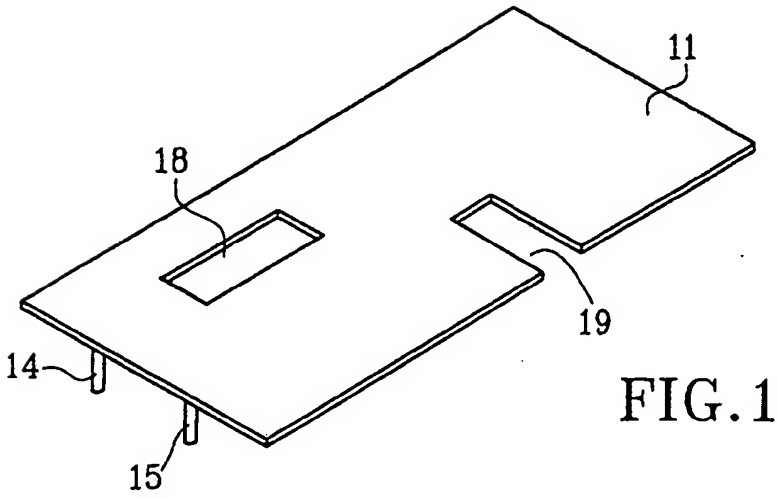

FIG.10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01513

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01Q 1/38
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5821902 A (K.M. KEEN), 13 October 1998 (13.10.98), figure 5a --	1-17
A	US 4766440 A (M.J. GEGAN), 23 August 1988 (23.08.88), cited in the application --	1-17
A	US 4692769 A (M.J. GEGAN), 8 Sept 1987 (08.09.87), cited in the application --	1-17
A	US 4356492 A (C.M. KALOI), 26 October 1982 (26.10.82), cited in the application --	1-17

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 November 2000	16 -11- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Rune Bengtsson/AE Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01513

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5764190 A (R.D. MURCH ET AL.), 9 June 1998 (09.06.98), cited in the application -- --------	1-17

INTERNATIONAL SEARCH REPORT
Information on patent family members

03/10/00

International application No.
PCT/SE 00/01513

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				WO	9506962	A	09/03/95
US	4766440	A	23/08/88	NONE			
US	4692769	A	08/09/87	NONE			
US	4356492	A	26/10/82	NONE			
US	5764190	A	09/06/98	NONE			